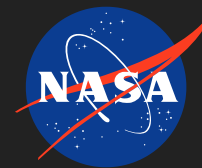


Ignition Susceptibility of Additive Manufactured Inconel 718 in Oxygen by Subsonic and Supersonic Particle Impact

Completed Technology Project (2016 - 2017)



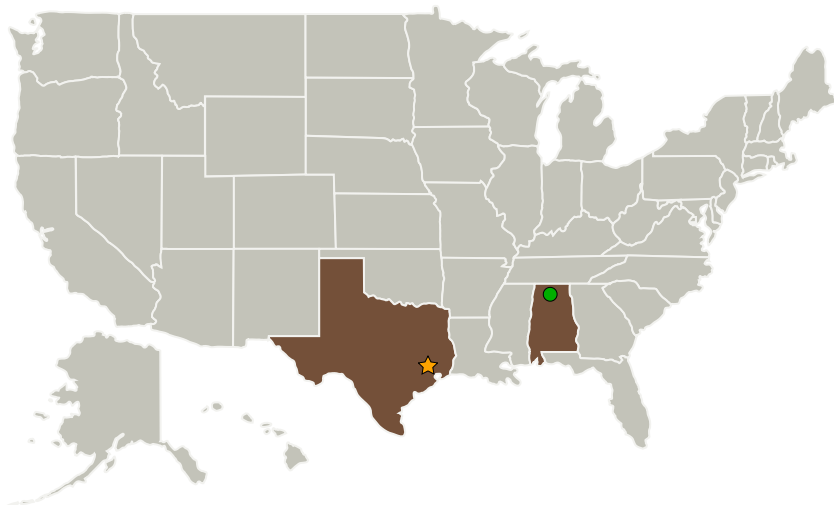
Project Introduction

TRL Steps will be archived in 1 year by performing the first ignition testing in a relevant laboratory environment (high pressure, high temperature oxygen) of many possible factors affecting the ignitability of SLM Inconel 718. These results can then be applied to compatibility assessments of future and current components that helps designers and management to make informed decisions about risk.

Anticipated Benefits

Parts produced by Additive Manufacturing (AM), particularly Selective Laser Melting (SLM), have been shown to silt metal particulate even after undergoing stringent precision aerospace cleaning processes (Lowrey 2016). Required pressures, temperatures, and flow rates in oxygen systems are increasingly exacerbating the hazard of Particle Impact (PI), the most common direct ignition source of metals in oxygen enriched environments. As the use of AM parts in oxygen systems becomes more common their PI susceptibility must be evaluated. This type of ignition testing has never been performed on AM metals and WSTF maintains the only flowing PI test facility in existence. Evaluating ignition of these metals is a critical step for evaluating the safety of current and future low cost high performance engine technology and advanced environmental control and life support systems. This will be the first systematic study of the ignitability of additive manufactured metals in oxygen systems.

Primary U.S. Work Locations and Key Partners



Ignition Susceptibility of
Additive Manufactured Inconel
718 in Oxygen by Subsonic and
Supersonic Particle Impact

Table of Contents

| | |
|---|---|
| Project Introduction | 1 |
| Anticipated Benefits | 1 |
| Primary U.S. Work Locations and Key Partners | 1 |
| Project Transitions | 2 |
| Organizational Responsibility | 2 |
| Project Management | 2 |
| Technology Maturity (TRL) | 2 |
| Stories | 3 |
| Technology Areas | 3 |
| Target Destinations | 3 |
| Supported Mission Type | 3 |

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| Organizations Performing Work | Role | Type | Location |
|--------------------------------------|-------------------------|-------------|---------------------|
| ★ Johnson Space Center(JSC) | Lead Organization | NASA Center | Houston, Texas |
| ● Marshall Space Flight Center(MSFC) | Supporting Organization | NASA Center | Huntsville, Alabama |

Primary U.S. Work Locations

| | |
|---------|-------|
| Alabama | Texas |
|---------|-------|

Project Transitions

▶ **October 2016:** Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Johnson Space Center (JSC)

Responsible Program:

Center Innovation Fund: JSC CIF

Project Management

Program Director:

Michael R Lapointe

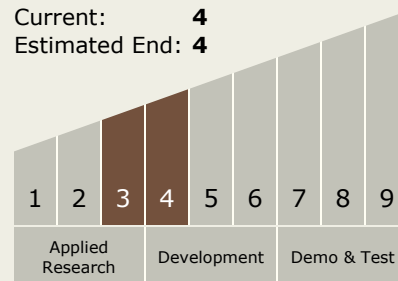
Program Manager:

Carlos H Westhelle

Principal Investigator:

Jonathan M Tylka

Technology Maturity (TRL)

Start: **3**Current: **4**Estimated End: **4**

Ignition Susceptibility of Additive Manufactured Inconel 718 in Oxygen by Subsonic and Supersonic Particle Impact

Completed Technology Project (2016 - 2017)

**July 2017:** Closed out

Closeout Summary: Supersonic and subsonic PI testing was performed over the last year and reporting is currently in process. Supersonic PI testing resulted in several observations that provide insight into some of the performance differences between wrought 718 and AM SLM 718 produced in the study. With respect to surface finish, three key observations were made: 1) SLM samples that received HIP and electro polishing (EP) lost less mass than SLM HIP samples with either mechanical polishing or chemical etching (CE) when impacted; 2) SLM HIP CE samples lost significantly more mass than non-HIP CE samples when impacted; and 3) in highly polished wrought samples, a higher mass loss was observed than for samples machined to a surface finish of RMS 125. With respect to heat treatment, SLM and wrought samples that received AMS 5664 solutionizing and aging were not observed to have different ignitability properties when compared to annealed samples. Subsonic testing resulted in two key observations: 1) Even without ignition SLM samples lost more weight than wrought samples, likely due to particle silting from the SLM samples during exposure to high flow; and 2) SLM powder is highly flammable. An important lesson learned is that, when exposed to high pressure and temperature when contained in the subsonic particle injector, SLM powder will ignite before injection into the flowing gas. This will have particular impact for engine designers who are subjecting SLM parts to high temperature and pressure inside the engine environment. Another important accomplishment was the first ever successful measurement of a supersonic particle entrained in heated oxygen with photon Doppler Velocimetry. The particle was measured at ~1350 ft/s. This will have impact on the fidelity of data collected as part of routine PI testing and as a critical piece of information for PI modeling efforts. Also, we accomplished the first demonstration of particle impact ignition of wrought materials with inert particles during baseline testing. The JSC IRAD has funded the WSTF Oxygen Group and its collaborators to come up with a preliminary design for a PI test system with higher fidelity PI testing at the pressures and temperatures demanded by current and future advanced engine performance.

Stories

Testing Phase Plan

(<https://techport.nasa.gov/file/36984>)

Technology Areas

Primary:

- TX04 Robotic Systems
 - ↳ TX04.3 Manipulation
 - ↳ TX04.3.4 Sample Acquisition and Handling

Target Destinations

Earth, The Moon, Mars

Supported Mission Type

Planned Mission (Pull)